

Summary
Steller Sea Lion Recovery Team Meeting
NMFS Alaska Region, Juneau, Alaska
7-9 May 2003

Bob Small, Chair of the Steller Sea Lion Recovery Team (SSLRT or RT), opened the meeting at 08:35 on May 7. Regional Director Jim Balsiger welcomed RT members to Juneau and thanked them for their efforts. After Small reviewed the agenda, Loughlin reported on a meeting of geneticists that took place in Seattle on April 17-18 to evaluate the applicability of a boundary ranking analysis currently used by the Southwest Fisheries Science Center (SWFSC) for harbor seal population studies. The group concluded that the boundary ranking technique could be powerful and useful for SSL studies when used in conjunction with nested clade or other analyses. They suggested that all of these methods be discussed during a workshop to consider whether a third SSL DPS should be established, and are awaiting approval from the region to hold that workshop in late summer or early fall. Payne observed that the evidence is already compelling and that a workshop may be unnecessary, especially if it might delay completion of the RP. Others suggested that a genetics workshop could provide scientific validation for NMFS action, citing the Eastern/Western DPS split that occurred in 1997 after the concept was presented at a similar workshop. Sponsorship and funding for the workshop are still undetermined.

Capron reported that NMFS has drafted an addendum response to the court's remand of the 2001 Biological Opinion (BiOp) and will provide it to the North Pacific Fishery Management Council (NPFMC) and the public for comment in early May. NMFS is responding to two issues in that remand: (1) the use of telemetry data, and (2) how specific management actions changed patterns of fishing. Capron characterized the comments received to date as positive and supporting. The final response to the remand is expected by June 30. Capron believed that completion of that final response would end that series of litigation. RT members asked whether the RT would review that response, and Capron suggested that it could be included in the redrafted Section IV. Capron also noted that the NPFMC Mitigation Committee is discussing possible applications of the fisheries research proposed in the National Academy of Sciences report for the 2005 management plan. Small agreed that the RT should examine the addendum as it completes Section IV, and consider whether it should advise the Mitigation Committee on the approaches it takes.

Nutritional Stress – Introduction

Trites and Atkinson led the evaluation of nutritional stress in SSL. They divided the evaluation into two sessions, the first consisting of a series of formal presentations and the second a RT assessment of the available data. The presentations were envisioned as overviews to provide RT members with sufficient background to understand and evaluate whether SSL are nutritionally stressed. In the second session, RT members were expected to define nutritional stress, evaluate the data to determine whether nutritional stress currently exists and should still be listed as a threat, and develop a matrix of probable impacts of nutritional stress on SSL. Small distributed a

series of questions to be answered during the evaluation, including: are the data available that are needed to quantitatively link the functional relationship between food and SSL demography – and if not, to what degree do the available data permit an adequate evaluation of the threat of nutritional stress, which aspects of SSL life history are most sensitive to nutritional stress, , alternative explanations for evidence of nutritional stress, research priorities, and whether the RT should attempt to identify the ultimate sources of nutritional stress.

Historical SSL Food Habits Information

Lowell Fritz, National Marine Fisheries Service

Fritz presented a summary of historical SSL food habits data as a spreadsheet for the Eastern and Western DPSs. Data included the year, season (with sample size), region, age and sex of individuals, type of sample, location of sample (land vs. at-sea), prey items present, and literature reference. The tables included samples collected during 1945-2000 from the Western DPS and during 1901-1993 from the Eastern DPS. Studies generally included one of four basic types of information: (1) opportunistic samples, (2) relatively undocumented observations, (3) summer collections of adult males on rookeries, and (4) broader collections of males, females, or juveniles on summer rookeries. There are questions regarding the quality of fish identification in several of the studies. Studies from the 1970s and 1980s were generally more complete and the first to look closely at differences between what were to become the Eastern and Western DPSs. Studies using scat samples became prevalent in the U.S. during the 1990s due to restrictions on direct collection; age determinations became less available in those reports. Fritz did not attempt to characterize prey by its frequency of occurrence, merely noting its presence and whether it represented the dominant prey type recovered. He believes that pre-regime shift studies do not characterize conditions during that period due to their small sample sizes. Relatively fewer studies were found describing the Eastern DPS (8 vs. 17 for the Western DPS), but some seasonal and geographic differences begin to emerge; RT members suggested other studies that might be included.

RT questions and discussion:

- Some RT members were concerned about use of the term “dominant” relative to prey species and questioned its working definition. Fritz noted that some studies reported percentage volume while others used frequency of occurrence. He found it difficult to interpret frequency of occurrence when sample size were very small or when researchers know that the samples were not reflective of SSL diets at the time.
- Some RT members believed that the early SSL data were too crude to demonstrate regime shift. Sinclair encouraged RT members to evaluate each study individually. She noted that there are biases in the collections from all periods, and that the RT will have little usable data if it becomes too mired in those biases. She encouraged the RT to make use of historical studies that look across predators (e.g., fur seals, birds, etc.) for evidence to support ecosystem change hypotheses.

Seasonal and Spatial Diet Patterns From the Western Stock of Steller Sea Lions, 1990-1998
Beth Sinclair, National Marine Fisheries Service

Recent diet studies have examined 41 sites that extend west from the central Gulf of Alaska in an attempt to describe current diet trends and seasonal patterns. Samples have been equally distributed between summer (May-September) and winter (December-April) periods, but sampling at the site level was variable. Diet at each site was described using frequency of occurrence. Across the range nine species ranked above 5%; the top four species were pollock, Atka mackerel, salmon, and Pacific cod. Animals on islands grouped in close proximity generally displayed similar diet patterns. Principle component and cluster analyses were used to identify three prey groupings or clusters. Cluster 1 (mackerel and cephalopods) was characteristic of Region 4 (Western Aleutians), while Cluster 2 (arrowtooth, salmon, pollock) was characteristic of Region 1 (east of Kodiak). Cluster 3 (herring, cod, sandlance, Irish lords) was characteristic of Region 3, while Region 2 displayed an overlap of clusters 2 and 3. Regional comparisons used Chi-square and Shannon's Index of Diversity. Significant seasonal differences in frequency of occurrence were noted, with some species more common during seasons when those species were making large seasonal movements. These prey come to SSL and SSL need not travel far to encounter them. Prey diversity was highest during the winter period in all but Region 2; winter was also characterized by the highest frequency of juvenile and adult male samples in the database. Seasonal and regional patterns in prey composition were strongly defined, suggesting foraging site fidelity.

SSL populations in regions 1 and 4 declined slowly during the late 1980s and 1990s, while populations in regions 2 and 3 were stable or increasing. Diet divisions closely matched metapopulation declines, and diet diversity was highest in regions showing the greatest population stability. Sinclair suggested that strong foraging site fidelity may enable some linking mechanism between diet and population trends. If female SSL stay in a region, forage in that region, and their pups stay in that region, they may be getting feedback on environmental stability or other factors. Localized prey depletions could then impact SSL populations in an area.

RT questions and discussion:

- Some RT members noted that the SSL populations characterized by Sinclair as “stable” or “increasing” had already experienced significant declines. Others noted that the existence of regional differences in food composition and population decline does not necessarily prove a linkage. Still others recognized that SSL are able to seek out and utilize seasonal prey aggregations that are often far removed from haulouts, and acknowledged that traditional sampling practices may under-represent these concentrations. Sinclair maintained that the data are compelling, and that there seem to be differences in diet from region to region that are connected to other patterns.
- RT members questioned whether methodologies changed over the sampling period. Sinclair replied that the use of reference collections by species has not changed, but researchers' ability to identify the size of prey has improved through the use of other bones in addition to otoliths. She suggested that the size of pollock in SSL diets is now known to overlap the size targeted by trawl fisheries. These changes do not affect the species compositions reported in studies from the 1990s.

Gulf of Alaska Predator/Prey (GAAPP) Studies

Kate Wynne, University of Alaska, Kodiak

This research is designed to test for prey differences between sites and seasons around Kodiak. The program has collected approximately 2,400 SSL scats from ten haulouts (six primary sites) on a monthly rotation of 1-3 sites, and approximately 750 of those samples have been analyzed to date. Researchers have collaborated closely with NMML to maximize funding for air time and laboratory labor. Samples have displayed high diet diversity and richness. Over 36 prey species have been identified, and 1-9 prey species commonly appear in a scat. Nine prey species appear in more than 10% of scats and six appear in more than 20%. Arrowtooth are a common prey species year-round, while salmon and capelin are important seasonally. Although the three northernmost sites show some differences from the three easternmost sites, Wynne did not suggest a firm division between those sites since animals are known to move between areas. There is high variability between months at a site, and between sites.

RT questions and discussion:

- RT members noted that sandlance are physically small but are the most frequently occurring prey species and questioned whether they are truly dominant or a secondarily consumed item. Small bones are less likely to pass through the gastrointestinal tract intact, but Wynne noted that some scats contain many of these bones. Researchers consider the consumption to be primary if the condition of those bones is equivalent to that of other primary prey remains. It is not feasible to assess the available biomass of sandlance, but Wynne has collected samples for energetic analysis.
- Wynne noted that the sample of summer scats is relatively small because researchers wish to limit disturbance of animals on rookeries during that period. In order to compare Wynne's diversity measures with those of Sinclair, new collections of material during the summer on rookeries will be needed.
- RT members were struck by the energy-rich nature of the SSL diet near Kodiak and discussed its possible implications. While many considered diversity a favorable trait, others suggested that it could be either good or bad. They suggested that it could indicate that a major prey item was absent. Since most of Wynne's samples came from juvenile animals, they also suggested this could indicate inexperience in foraging.

Nutritional Studies at the Alaska Sea Life Center (ASLC)

Mike Castellini, Institute of Marine Science, University of Alaska, Fairbanks (via telephone)

Castellini described a 2-year feeding trial with harbor seals in which each animal was fed daily to behavioral satiation on a diet consisting of 100% pollock for one year and 100% herring for one year (each animal acting as its own control). Researchers conducted a series of short-term studies during each trial in which test animals were confined in a metabolic cage for 48 hours, fed a specified amount once per day, and all inputs and outputs were measured. Weight gain/loss over the period of confinement was minimal. Fat content in scat was measured by lipid extraction from dehydrated samples. Body condition was measured through total body water with deuterium, BIA, and length/girth/mass relationships. Researchers could detect no pattern

by which they could predict body condition by diet. They could detect seasonal differences and signals in the response of animals to the diet and in blood chemistry, but not in body mass or other traditional measures of condition. Harbor seals exhibited different metabolic rates at different times of the year. At one time of the year harbor seals would gain weight on a diet, while they would lose at other times of the year (e.g., they would lay on fat during the winter and lose fat during summer, regardless of the amount or quantity fed). Castellini remembered periods when animals gained weight regardless of diet, but could not remember whether they had actually lost weight when eating herring. Harbor seals adapted to diet by adjusting their digestive assimilation and the volume they consumed. Excess fat from the 100% herring diet was excreted, so caloric assimilation from the two diets was similar. Fat excretion was characterized by a linear function; i.e., as more fat was fed more was excreted. Harbor seals ate more dry matter of pollock than herring, and could process pollock faster than herring. Since test animals were not engaged in active foraging, these findings relate only to metabolic activity and not to prey availability or ease of capture.

A similar 3-year trial has recently been completed with SSL. Researchers tested three diets that were more complex and intended to mimic the pre-decline, post-decline, and Southeast Alaska diets described by Burkanov/Calkins. These diets differed from those in the harbor seal trials in both calorie content and composition, including herring, salmon, capelin, pollock, and other species. Three animals were tested (one for each diet), test animals were not caged, and blood samples were not collected as frequently as in the harbor seal studies. Although the first draft of this study is not due until September, there have been some clear seasonal signals. The winter/summer (July/November) responses of animals fed the pre-decline and Southeast diets are different from those on the post-decline diet. Summer calorie consumption is relatively constant, but becomes highly variable in mid-October. The patterns of amount consumed, calories consumed, and seasonal consumption are complex and are affected by other seasonal and individual metabolic patterns.

RT questions and discussion:

- Extended RT discussion focused on apparent differences between the studies conducted by the ASLC and the NPUMMRC. One male and two female SSL were used in the ASLC study, and at 6-9 years they were becoming sexually mature. RT members were concerned that the male's growth patterns during those years would not be comparable to the females', and that issues of hormone status must be considered. Atkinson reported that the recent behavior and growth patterns of this particular male are even more pronounced, and he is putting on weight and acting more like a free-ranging male. Castellini agreed that juvenile animals could respond differently from adults when fed the same diet during the same season, and that the response of the SSL aged 6-9 years used in the ASLC studies could be very different than the responses of those aged 1-3 years in the NPUMMRC studies. RT members recommended that the studies be replicated using younger animals; permit requests to conduct such work have already been submitted.
- In response to RT questions, Castellini noted some of the differences between phocids and otariids. Otariids consume more per unit body weight than phocids. Phocids and otariids likely metabolize fat differently, and protein turnover studies have shown that they definitely metabolize protein differently. Harbor seals have more blubber than SSL and are more willing to let blubber thickness vary. Lipid content is critical for SSL, and

Castellini suspects they have buffering systems to compensate for seasonal intake differences. Researchers have not extensively examined protein and carbohydrate metabolism in SSL because they are not significant calorie sources. Protein and carbohydrate are being reexamined with the new awareness of seasonal metabolic differences in SSL.

- Castellini stated that the ASLC studies cannot confidently predict response under field conditions, but suggest that the blood chemistry and physiology of these animals were responding to factors that were not controlled in the experiment (i.e., not to diet). SSL have complex physiological and biochemical demands to meet simultaneously that they somehow balance in order to stay healthy. Age and season must be considered when evaluating the effects of diet. He believes that simply changing food or diet is insufficient to be predictive of SSL body condition. Regarding the “junk food” hypothesis, Castellini believes that the ASLC laboratory studies do not suggest that food quality is sufficiently important to adversely affect survivability in the phocid age groups examined (no animals younger than two years). Quantity may be another matter; sufficient caloric input must be maintained.
- The ASLC has proposed two sets of experiments for future research. One series would work with younger ages of harbor seals and SSL to understand how they handle and process lipids, while another series would investigate protein and carbohydrate metabolism.

Diets of SSL in Southeast Alaska

Andrew Trites, North Pacific Universities Marine Mammal Research Consortium

These studies analyzed scat collected at Forrester, Hazy, and White Sisters islands primarily during the summers of 1993-1999. Sixty-one prey species were identified in the 1,565 scats (average 2.08-2.56 species per scat), making the region one of the most energy-rich in Alaska. While the diets at each of the rookeries were somewhat different, there was no overall change in the diet during this period. Some of the prey species occurred infrequently, but nine species were considered dominant (includes: herring, sandlance, salmon, pollock, rockfish, flatfish, and skates). When samples from the Forrester rookery (predominantly from female SSL) were compared to those from the nearby male haulout, they suggest that mature male SSL do not eat the same prey as mature females. Summer female scats contained forage fish, salmon, and pollock at roughly equal frequency (about 60%), with all other categories represented at 30% or less. Salmon occurrence in mature male scats was less than 10%, forage fish were about 45%, and pollock were about 70%. Seasonal changes in diet were detected, and the diet diversity index was highest during the summer and lowest during the fall (September-November).

RT questions and discussion:

- RT members suggested it would be helpful if the groups working with scat analysis could standardize their units to facilitate comparisons. Trites noted that processing techniques have largely been standardized, but the approaches to analysis have differed. Some groups report species groupings while others retain individual species identifications.

- The RT discussed the utility of various methods in addition to scat analysis used to identify prey. Depending on the question being asked, each technique has merits. Scat samples are easy to collect and provide insight into the significance of particular prey to the population. Biopsies for fatty acid analysis are more difficult to collect, but for individual animals can provide an estimate of proportional consumption and consumption over time. Stable isotope analyses detect changes in feeding at the trophic level, and may be useful to identify weaning.

Seasonal and Spatial Variability of SSL Prey Species

Johanna Vollenweider, National Marine Fisheries Service - ABL

These studies examined the nutritional quality of SSL prey species as measured by energetic value (calories) and proximate composition (lipid/protein/carbohydrates/moisture/ash). Prey quality can vary depending on the species, location, season, ontogeny, size, and gender. Researchers examined pollock (3 size classes), hake, herring, eulachon, and capelin on a quarterly basis from the Benjamin Island haulout and the Frederick Sound haulout. Eulachon were found to have the highest energy density, followed by herring, capelin/hake, and the three pollock size classes. Approximately 70% of the energy in eulachon is derived from lipid and 30% from protein; as lipid content declines in the other species a greater proportion of the caloric content is derived from protein. Lipid content shows greater variability than protein content; eulachon had the highest lipid content while herring had the highest protein content. Moisture content is inversely related to lipid content.

Most variability in prey quality is explained by season, but there is some overlap in prey quality. Eulachon were generally the best source of energy content throughout the year, although herring was somewhat higher during December. Herring were the best source of protein throughout the year. Hake/capelin/pollock generally had higher moisture content throughout the year. Pollock generally showed no variability in lipid content by location or by gender.

There appear to be linkages between prey quality and SSL foraging patterns. During the winter SSL consume herring, which is a good source of lipid and protein for fattening, gestation, and nursing. Large aggregations of herring in prime condition are available during this season. Eulachon and pollock are prevalent during the spring breeding and pupping period, and spawning aggregations of eulachon and herring are frequently targeted. Herring and hake are prevalent during the growth and nursing periods.

RT questions and discussion:

- RT members asked whether prey quality varies from year to year. Vollenweider replied that the time series data to address this issue are still being collected. Some seasonal variation has been detected but it is too soon to determine if the annual cycles will hold.
- RT members asked whether the results could be compared to earlier studies. They were cautioned that earlier samples were often collected from a single site/time, or were collected opportunistically over time and pooled so seasonal variability was lost.
- Some RT members were surprised that prey energy content often declines with spawning, apparently due to the large quantity of energy expended to produce gametes. Others

suggested that the tight linkage between foraging and prey quality was not supported by SSL that feed on aggregations of spawning herring. Since herring are a good source of protein throughout the year, however, there could be other explanations. Some also questioned how large a proportion of the SSL population targeted these aggregations and how important this practice was in the nutritional status of those involved.

NPUMMRC Captive SSL Experimental Diet Trials

Andrew Trites (for David Rosen), North Pacific Universities Marine Mammal Research Consortium

The NPUMMRC (Consortium) has raised 15 SSL pups since 1993, currently has eight, and plans to capture six more later this year. The Consortium's captive SSL research program investigates many of the hypotheses related to the SSL decline and is a bridge between field observations and conjectures from animal and computer modeling. The Nutritional Stress hypothesis assumes that certain foods are less valuable to SSL than others. Tests of fish from feeding trials show the strong and not surprising relationship between lipid content and gross energy content of various prey; 60% differences between pollock and herring are not unusual. Net energy content of prey (after energy lost during digestion – heat increment of feeding) is, however, the biologically relevant parameter to an individual. Foods with lower energy content required more energy to digest, so the energetic differences seen at the gross energy level were increased when the net energy values were calculated. SSL should increase their food intake when switched from a high energy to a low energy food (compensatory food intake), but Consortium researchers did not find this to be the case in a series of two-week experiments. Test animals took in less energy and body mass decreased, and a decrease in their resting metabolic rate indicated a physiological fasting response. When subjected instead to a restricted diet, the metabolic rate of test animals increased – typical of a foraging response – suggesting that energy-sparing adaptations may not be triggered if the energy imbalance is due to a decrease in prey availability rather than to reduced prey quality.

Armed with these initial results Consortium researchers began a series of diet manipulation studies designed to (1) quantify the energetic and nutritional requirements of individual SSL, (2) understand how animals adjust food intake based on prey availability and composition, and (3) quantify the physiological consequences of ingesting inadequate prey. A long-term goal of this work is to provide diagnostic tools to ascertain the status of SSL in the wild. These studies relied on treatment amplification (e.g., single prey species, relatively high lipid vs. relatively low lipid) to compensate for unavoidably small sample sizes. Trials were short term (10-30 days rather than three years) to focus on likely scenarios of short-term diet changes or decreases and to limit potential health impacts to test animals. Feeding levels were controlled due to the nature of the manipulations and to reduce potential biases of performance-based food intake levels.

One experiment examined the effects of a low-lipid versus high-lipid diet. Animals alternately maintained on isocaloric diets of herring and pollock showed no differences in overall growth rate, but animals on the low-lipid diet had lower body condition and lipid reserves during periods of high seasonal body growth (growth spurts). A second experiment examined the impacts of the inability to consume adequate prey by maintaining test animals on isocaloric diets calculated to produce 10-15% reductions in body mass over 30 days. Animals again displayed no differences

in growth rate, but showed significant changes in relative body condition and absolute lipid stores. Initial results suggest that animals consuming a low-lipid diet may have greater susceptibility to oxidative stress, reduced availability of key fat-soluble vitamins, and possibly a differential cytokine response. Sample analysis of these parameters is ongoing.

A third experiment – currently underway – examines the effects of very low energy intake levels on body mass and composition and on hormone levels. It employs seasonal food restriction (10 days every three months) to assess whether short periods of under-nutrition can have significant physiological effects that might be compounded during critical periods. Two of the seasonal trials have been completed, and the experiment is scheduled for completion this fall. The final experiment investigated the maximum food intake of young SSL, documenting how quickly they altered food intake in response to changes in prey quality and availability. Juvenile SSL were alternatively offered herring or capelin ad lib either daily or on alternate days. With daily herring as a baseline, researchers expected (based on energy content) the test animals would consume twice as much herring when fed on alternate days, 83% more capelin than herring when it was available daily, and 3.5 times more capelin than herring when it was available on alternate days. While daily food expectations for herring (by definition) and capelin were met, test animals did not consume quite enough herring, or the massive amounts of capelin, required by this model to maintain energy intake when fed on alternate days. They appeared to hit a digestive ceiling for food intake at a level equivalent to 15-18% of their own body mass.

From these experiments Consortium researchers conclude (1) digestive efficiencies associated with low lipid prey tend to magnify the gross energetic difference between prey items, (2) SSL can increase food intake to compensate for differences in prey quality and availability, but at some point decreases in prey quality and availability combine to necessitate food intake levels that exceed the digestive capacity of the individual, and (3) if sufficient food can be obtained to meet energetic requirements, there is no evidence that prey quality affects body mass or condition. If energy intake is insufficient, however, lower lipid prey can adversely affect body condition, absolute lipid reserves, and other indicators of health status. Imbalances in SSL energy budgets can result from changes in energy intake or energetic demands, and young animals and reproductive females are likely to be most at risk. If energy intake is limited, SSL possess physiological mechanisms (e.g., metabolic depression) to minimize but not eliminate the energy imbalance. These adaptations may not be triggered if the energy imbalance is due to decreased prey availability rather than reduced prey quality.

RT questions and discussion:

- The RT discussed the merits of comparing food sources on the basis of either dry or wet weight. Some maintained that dry weight is the only appropriate measure when judging the net energy values of herring versus pollock. Trites suggested that wet weight was appropriate for captive studies when determining how much to feed. Although there is no indication that moisture is a limiting factor for SSL, stomach capacity may be a limiting factor. When asked (via telephone) why energy comparisons of pollock and herring were stated in wet weight terms, Rosen replied that the energy content of fish is not affected by the packaging, although the presence of moisture does reduce the energy density.

- Since assimilation efficiencies for all foods were 90% or more, some RT members questioned whether these represented anything more than a statistical relationship. Trites suggested that differences of 10% might have a biological significance for younger animals who may be living on the edge with high energy needs.
- RT members asked Rosen (via telephone) about the most appropriate way to calculate body condition. Rosen noted that current the research trends away from the use of body size ratios toward absolute lipid mass as an attempt to quantify lipid reserves.
- Rosen noted (via telephone) no inconsistencies between work conducted by the NPUMMRC and the ASLC. If older animals can get enough fish, regardless of quality, they will consume enough to maintain body mass. An issue of contention appears to be whether animals with the highest energy needs can ingest that much fish.

Toward Testing the Nutritional Stress Hypothesis in Free-Ranging SSL

Lorrie Rea, Alaska Department of Fish and Game

After reviewing medical definitions of stress, malnutrition, undernutrition, fasting, and starvation, Rea listed several physiological and ecological indicators. Evidence of starvation in seals and SSL during catastrophic fisheries failures have included high early pup mortality, low birth weights, slow pup growth and emaciation, high rates of abortion, adult females in poor body condition, and longer foraging trips made by nursing mothers that result in longer fasting periods for the pups. Evidence of fasting in SSL from captive controlled fasting trials include mass loss, decreases in percent body fat and blubber depth, no change in hematology but blood chemistry changes after seven days, and metabolic depression. Evidence of food limitation in SSL from captive controlled 28-day trials include mass loss, decrease in percent body fat and blubber depth, no significant changes in either hematology or blood chemistry, and no consistent metabolic depression. Other studies have looked at micronutrients (vitamins A & E, elemental signature analysis), hormones (thyroid hormones, cortisol, leptin), and stress factors (haptoglobin).

Indices of body condition include body mass, standard length, axillary girth and additional girth rings, and percent body fat. There is good evidence for losses in body mass during complete fasting, but there are difficulties associated with the use of body mass in a sexually dimorphic species. The sexes must be examined separately in each geographic area, and longitudinal data (e.g., mean growth rates of branded pups recaptured as juveniles) should be examined. SSL decrease body fat while fasting, but there are also problems peculiar to each of the methods used to measure blubber reserves (direct measure, ultrasound, skinfold calipers, heat flow measurements, deuterium dilution, and bioelectrical impedance analysis (BIA)). Fatty acid signature analysis attempts to identify diet composition by determining what mixture of prey fatty acid signatures comes closest to matching the fatty acid signature of the predator after accounting for the deposition and biosynthesis characteristics of individual fatty acids within the predator. The effort is difficult and data intensive, but there has been some success in distinguishing animals that appear to be primarily dependent on milk from those ingesting prey with a different signature. Stable isotope analyses of vibrissae, ingested milk, and blood can be used to identify trends in the trophic level of the diet. Although less specific about individual prey items, they can provide a timeline through analysis of the vibrissae. As expected, nitrogen

isotope ratios for pup vibrissae roots were at a trophic level higher than the milk signature, suggesting another potential weaning indicator.

Evidence of poor nutrition in SSL during the 1980s include significantly lower body size of individuals aged 1-10 compared to the 1970s, lower pregnancy rates, change in diet (from stomach contents), possibly depressed hemoglobin levels, and concurrent declines in harbor seals, fur seals, and some piscivorous sea birds. Evidence supporting the nutritional stress hypothesis in the 1990s include a diet composition similar to the 1980s (from frequency of occurrence in scats), and high haptoglobin concentrations in the area of decline suggesting the possible presence of a non specific stressor. Evidence in conflict with the hypothesis includes the lack of high pup mortality or poor adult female body condition, similar birth weights of pups in the east and west, faster growth rates of pups in the declining population, no blood chemistry or hematology evidence of poor pup health in the east or west (except haptoglobin in the areas of decline), blood chemistry evidence of longer fasting periods in eastern pups, and longer perinatal period and time spent nursing in the western DPS. The 1990s data suggest that (1) although diet composition of western animals had not changed, adult females appeared able to secure enough food to adequately nurse their pups within the first 4-6 weeks of lactation, and (2) if food limitation continues to be a major cause of continued declines it may affect larger, late-lactation pups and newly-weaned juvenile SSL, resulting in low recruitment to the breeding population. During the 21st century there has been no evidence of high pup mortality, low birth weights in the west, nor evidence of poor growth of pups in the area of decline. Body fat contents are highly variable in both areas at 15 months of age, and juveniles appear to ingest prey during their first year in Prince William Sound but do not show distinctive foraging signatures in the first two years in Southeast Alaska.

RT questions and discussion:

- Some RT members questioned how pups could be larger in the area of decline, and why pups would be nursing for two years in Southeast Alaska if food conditions were supposedly so good. They questioned whether researchers might be looking at just the healthy survivors in the west. Rea replied that there is no evidence of major food limitation in the west. Animals are not starving, but the effects of prey quality could be subtle. Examining aggregations of animals potentially biases the studies, but researchers have looked at animals at various times of the year and have compared between areas without detecting the typical things they would expect. Pup numbers are still declining, so either pups do not recruit to the breeding population or there are a lot of female SSL somewhere that have not given birth.

Bioenergetic Modeling of SSL in Alaska

Arliss Winship, North Pacific Universities Marine Mammal Research Consortium

These studies examine the processes of energy transformation, loss, and acquisition and attempt to predict and quantify the relationship between SSL and prey consumption. Bioenergetic modeling may present fewer problems than more direct methods of estimating the prey requirements of SSL like stomach content analysis (requires sacrificing animals) or captive feeding rates (questionable comparability to wild conditions). The bioenergetic model described here has been documented in two published journal articles. Inputs to the model include the

physiology/energetics of individual SSL, population size and composition, and the composition and energy content of the diet. Model outputs include the prey requirements of individual SSL by age, sex, season, and the prey requirements of the Alaska population of SSL. The model generates estimates using Monte Carlo simulation: parameters are defined by ranges rather than point estimates, the model is run to obtain a population point estimate using random selections from each parameter range, and the distribution of point estimates after a specified number of runs is examined.

The model suggests that the energy requirements of mature female SSL increase in late summer as these animals spend more time at sea. The energy requirements of a pregnant female would be somewhat higher than this baseline during summer as the fetus develops. Energy requirements for lactating females are very high in the spring when the pup is aged 1 year, and at that time the mother has a potential for energetic stress. The average mass-specific food requirements (percent body mass per day) on an individual level are higher for young animals than they are for older ones, suggesting another period when the chance of nutritional stress is increased.

The model can be used to estimate prey requirements on a population level, and Winship presented an example using 1998 population data and Merrick's 1990-93 summer diet composition data. There was significant variation in the amount of prey consumed in the seven geographic regions due to differences in the population size and the prey composition by region. The energy content of the regional diets varied by as much as 25%, and the amount of food required per individual was higher in regions with a low energy diet. A broader range of seasonal diet composition data are available for Southeast Alaska, and when these are considered they tend to increase the average daily food requirement. Per capita food requirements were also correlated with rates of SSL population change over the same period; declines were lower in areas with lower per capita food requirements. Quality and quantity of food are not necessarily two separate issues, because quantity affects the quantity an animal must consume. Sensitivity analyses suggest that bioenergetics information (basal activity, production, etc.) and diet composition information contribute most to model uncertainty.

A different type of model – a dynamic bioenergetics model – can be used to predict what happens to the individual or the population when energy requirements are not met due to reductions in prey density/availability or content. Energy in this type of model is an input parameter, and the model allocates this energy to each anticipated energy need. Winship considered as an example the demands of pregnant female SSL, with and without pups, on high and low energy diets. A female SSL with pup on a low energy diet needs an additional 20%+ body weight per day, and can compensate by reducing either pup growth or fetal growth below normal. The model suggests that the female derives more energy on an annual basis by reducing energy output to the pup rather than the fetus, except in March when the energy associated with similar percentage growth reductions are equivalent. This suggests that the cost of pregnancy for SSL is low and does not increase until near the end of pregnancy in spring. Lactation is energetically costly, especially in spring. Simulations with this model can also be used to predict growth of the mother and pup at different levels of maternal energy intake. An intake of 150 MJ/day is considered normal, and at 125 MJ/day the female loses mass and pup growth is stunted. At 100 MJ/day the pup dies in late winter/early spring, while at 50 MJ/day the pup dies

immediately and the female dies after several months. Work with this model has been limited to individual animals, specifically adult females. At this level there are many assumptions and additional work is needed to scale up to the population level.

RT questions and discussion:

- Some RT members suggested that if more recent data on the energy content of Atka mackerel were used, the difference between the energy content of eastern and western diets would not be as great. Winship replied that the model draws from a range of energy values for Atka mackerel that includes the new estimates.
- RT members observed that reductions in prey quality would require increased foraging, and could potentially cause increased removals due to predation. This factor might artificially appear to increase the growth rate of survivors. Winship noted that the model considers only physiological factors and not ecological ones. The potential disease and predation consequences of diet changes are not considered.

Nutritional Stress – Discussion

Led by Atkinsion, the RT began with the definition of nutritional stress suggested by Trites at the November 2002 meeting and worked to reach a consensus definition. After extended discussion they reached the following working definition of nutritional stress:

The physiological responses of Steller sea lions to suboptimal quantity and/or quality of available food that tend to disturb normal physiologic equilibrium (homeostasis) and directly/indirectly reduce survival and/or reproduction.

The RT then developed a matrix showing the presence or absence of potential biological manifestations of nutritional stress in the western DPS (Table 2). The RT focused on whether there was evidence to support the nutritional stress hypothesis during the most recent period, but retained columns for prior periods in case there is interest in assessing this threat historically. Some also expressed interest in adding reference citations. There was consensus that no evidence of acute nutritional stress currently exists. The question whether chronic nutritional stress exists generated extended discussion. While the RT could find no evidence directly supporting the nutritional stress hypothesis, many were reluctant to reject it as a factor in recovery. Several were concerned that most of the data come from rookeries in the summer, or from young animals that are still nutritionally dependent on their mothers. Some argued that there is no evidence supporting the existence of nutritional stress, since the four conditions designated with a “Yes” in Table 2 deal only with overall survival and could be caused by a variety of factors. Others deemed those as sufficient evidence. Some suggested that the question was irrelevant, since every population is a collection of individuals and all populations include some individuals that are nutritionally stressed. They maintained that nutritional stress at some level is a natural condition for any population at or near its carrying capacity. Others suggested that evidence from SSL should not be considered in a vacuum, and that the RT also needs to include evidence from the broader environment. Some were uncomfortable making a final characterization of the threat at this time, and wanted to evaluate it in the context of all other threats. Others suggested the RT should designate analyses of existing data (designated by

asterisks in Table 2) as action items, focusing on areas of greatest sensitivity. Small will draft supporting text to accompany the nutritional stress table and identify issues that will need to be addressed during the RT's assessment of this threat, and when combined with information presented and discussed during this meeting, will provide the foundation from which a working group (Trites (lead), Atkinson, Williams, and Rea) will prepare a draft revision to Section V.B.8.

RT members were generally unwilling to assign the task of identifying sources to a working group without further discussion. Small asked the RT whether it wished to devote another session, possibly with speakers, to identifying the sources of nutritional stress. Some thought it would be sufficient to state that there is insufficient evidence to demonstrate or dismiss nutritional stress as a threat, and reiterate the areas of uncertainty. They were unwilling to treat the presumptive threat as a proven fact. Small noted that if nutritional stress is still considered a threat to SSL recovery, the RP must address ways to reduce that threat. Some agreed with the workshop approach, while others thought it would be difficult to identify sources when RT members could not demonstrate with certainty that nutritional stress exists. They felt that the presentations would be similar to those at earlier meetings that addressed regime shift or the effects of fishing. Others feared that each source could be a workshop in itself, and that indeed some already had been. Some believed that the topic had already been covered exhaustively in several NMFS Biological Opinions. There was concern that the presentations would become merely a "review of reviews". Others wondered if the RT would need to treat all potential but unconfirmed threats with the same level of scrutiny.

Issues of scale were raised frequently, as was the need to include more than just information directly related to SSL, their prey, and fisheries. Some were concerned that the RT's approach presumed a homogenous Western DPS, when different threats may actually be operative in smaller areas. Others suggested that the RT consider the efficacy of fishery management measures taken in the past, since catch reductions that have occurred in some areas may alter the RT's views on whether nutritional stress has or is still occurring. The RT believed that a focused examination of a few smaller geographic areas might be helpful, and discussed which areas (including portions of WA/OR/CA) had the broadest range of information on SSL (population, diet, physiology, behavior), fisheries (catch and management restrictions), environmental monitoring, and other predators. Kodiak and Southeast Alaska were tentatively selected. Small and Wynne will develop a list of potential speakers and directions to focus their presentations. Stump remained concerned about how West Coast and North Pacific SSL populations may be affected differently by regime shifts; Small asked him to outline an approach that could be distributed for comment by the RT.

Status of Recovery Plan and Completion Schedule

After listening to RT discussion, Payne suggested that the RT presume that the Western DPS will be split at the international boundary. It is unlikely that a special meeting to consider the genetic issues will occur until fall. NMFS will probably designate a third DPS at some point, but that change can be made in the RP without that special meeting. The RT is not required to prepare a separate section for Asian stocks anyway, although RT members suggested that population data for those stocks still be included for perspective. Payne suggested that the agency is likely to

explore the genetic evidence as a scientific issue related to methods, and could broaden the discussion to include other species; e.g., harbor seals.

Small reported that sections III, V and VI (through V.B.10 and VI.B.10) are near final draft and can be completed once work on the threats table is finished. The RT chose not to begin a draft of the recovery strategy sections V.C and VI.C until after completion of the threat table. Byrd reported that the stepdown outline is nearing completion but the accompanying narratives are less well developed. A draft stepdown outline should be available soon for distribution to the RT. Small noted that additional work is still needed on the recovery criteria and on linkages between the threats table, listing criteria, five ESA factors, and recovery tasks. He suggested that the RT could focus on working in smaller groups once the recovery strategy has been developed, and that completed sections could be distributed for external review at that time.

Small suggested that the RT might wish to expand its discussion of essential habitat in the RP. He distanced this topic from the legal considerations associated with Critical Habitat, referring instead to a description of how SSL use space (where are they consistently observed, where do they forage, and why?). Small will develop a more complete description of his suggested approach and will circulate it to the RT for comment.

Small asked for RT reactions to the draft threats table compiled after the last meeting. He noted that he had insufficient time to compile the responses on geographic range. Several members asked for clarification on the nature of listed threats (e.g., non-human pollution, anthropogenic diseases, research, etc.) or on categories (e.g., difference between geographic occurrence and impact). Some questioned the utility of comparing RT estimates of loss in the threats table to the losses projected in the Loughlin/York model. Others voiced surprise that a particular threat (e.g., killer whale predation, disease, etc.) ranked so highly in the scoring. Some suggested that they had ranked threats improperly, basing their responses on whether a threat existed rather than on whether they believed it was limiting recovery. It was suggested that RT members focus on the top-ranking threats as a group, rather than on the order in which they were ranked by this exercise. There were no suggestions of alternative approaches to scoring. Entanglement in marine debris (discarded and active fishing gear, packing bands, tires, etc) was suggested as an additional threat. Hanson was asked to take the lead on completing this table.

SSLRT Meeting Schedule

The next meeting of the SSLRT was tentatively scheduled for the week of July 28, 2003 in Seattle. Specific dates will be determined later.

The meeting was adjourned at approximately 11:00 on May 9.

Table 1. Attendance at the meeting of the Steller Sea Lion Recovery Team held 7-9 May 2003 at the NMFS Alaska Region, Juneau, Alaska.

*	Shannon Atkinson	Alaska Sea Life Center
*	Linda Behnken	Alaska Longline Fishermen's Association
	Melanie Brown	National Marine Fisheries Service - SF
*	Vernon Byrd	U.S. Fish & Wildlife Service
~	Don Calkins	Alaska Sea Life Center
	Shane Capron	National Marine Fisheries Service, OPR
†	Al Didier	Pacific States Marine Fisheries Commission
*	Doug Eggers	Alaska Department of Fish and Game
*	Dave Fraser	F/V Muir Milach
*	Lowell Fritz	National Marine Fisheries Service
*	Tom Gelatt	Alaska Department of Fish and Game
	Brandee Gerke	National Marine Fisheries Service
*	Dave Hanson	Pacific States Marine Fisheries Commission
	Ron Heintz	National Marine Fisheries Service - ABL
	Sarah Hinckley	National Marine Fisheries Service - ABL
~	Lianna Jack	Alaska Sea Otter and Steller Sea Lion Commission
*	Tom Loughlin	National Marine Fisheries Service
*	Donna Parker	F/V Arctic Storm
	Mike Payne	National Marine Fisheries Service
*	Ken Pitcher	Alaska Department of Fish and Game
	Tim Ragen	US Marine Mammal Commission
	Lorrie Rea	Alaska Department of Fish and Game
	Beth Sinclair	National Marine Fisheries Service - NMML
**	Bob Small	Alaska Department of Fish and Game
~	Alan Springer	University of Alaska, Fairbanks
*	Ken Stump	
*	Andrew Trites	University of British Columbia & North Pacific Universities Marine Mammal Research Consortium
	Johanna Vollenweider	National Marine Fisheries Service - ABL
~	Terrie Williams	University of California, Santa Cruz
	Arliss Winship	North Pacific Universities Marine Mammal Research Consortium
*	Kate Wynne	University of Alaska, Kodiak
*	Steller Sea Lion Recovery Team Member	
~	Steller Sea Lion Recovery Team Member, absent	
**	Chair, Steller Sea Lion Recovery Team	
†	Rapporteur	

Table 2. Is there evidence of nutritional stress in the Western SSL DPS in the U.S.?

Potential Biological Effects	1970s	1980s	1990s	1990s-2000s
More emaciated pups (<4 wks)				U*
More emaciated pups (>4 wks)				U
More emaciated juveniles				N(H,G)
More emaciated adults				N(H,G)
Reduced pup survival (to 4 wks)				U*
Reduced adult body size				U
Reduced juvenile body size				U*
Reduced pup body size				N(G), U*(H)
Reduced birth weight				U
Reduced pup weight				N(G),U*(H)
Reduced growth rate				N(G)
Reduced pup survival				U*
Reduced juvenile survival				U
Reduced adult survival				U
Reduced overall survival				Y(H,G)
Reduced birth rate				Y(H)
Reduced pup counts				Y(H)
Reduced non-pup counts				Y(H)
Increased abortion rates				U
Change in pup blood chemistry (increased fasting)				N(G)
Change in juvenile blood chemistry (increased fasting)				U*
Delayed sexual maturity				U
Change in metabolic rate				U
Decreased body condition (adult females on rookeries)				U* (N(G))
Reduced adult perinatal fast				N(G)
Longer foraging trip duration				N(G)
Increased susceptibility to disease (haptoglobin)				U*
Increased incidence of disease				U
Increased susceptibility to predation				U
Altered weaning age				U*(G)
Decreased weaning size				U
Traditional ecological knowledge re. body condition				U*

Y = Yes

N = No

U = Unknown

* = Data are available

(H) = Historical, compared to the 1970s

(G) = Geographic, compared to the Eastern DPS

STELLER SEA LION RECOVERY TEAM
Draft Agenda

7-9 May 2003, Juneau, Alaska
Federal Building, NMFS Alaska Region
4th Floor Conference Room (#445C)

Wednesday, 7 May

8:30 am

1. Review and approval of agenda
2. *Western DPS structure: status of review/revision, 2001 BiOp addendum, other?*

9:00 am

3. Evaluation of Nutritional Stress – Andrew Trites & Shannon Atkinson, outside speakers

12:00 pm – Lunch Break

1:15 – 5:00 pm

4. Evaluation of Nutritional Stress (continued)

Thursday, 8 May

8:30 am

5. Evaluation of Nutritional Stress (continued)

10:30 am

6. Recovery Plan Revision
 - Background Sections III, V & VI (except B.10 for both)
 - Threat tables
 - Section IV
 - Outline & Narrative
 - PVA simulation results & parameterization
 - Plans for completion

12:00 pm – Lunch Break

1:15 – 5:00 pm

7. Recovery Plan Revision (continued)

4:30 pm

8. Set dates for next meeting, and determine major topics for discussion; source of nutritional stress (?), PVA model simulation results, recovery criteria, research reviews, etc.

Friday, 9 May

8:30 – 12:00 pm

9. Smaller groups meet separately
 - Threat tables, and cumulative and synergistic effects
 - Recovery Outline & Narrative
 - Recovery Strategy: Sections V.C & VI.C
 - Other?